

## PATENT ABSTRACTS OF JAPAN

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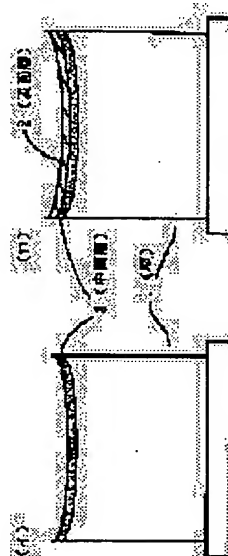
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## (54) MOLD FOR FORMING OPTICAL GLASS ELEMENT

## (57)Abstract:

PURPOSE: To make reactivity of a mold with lead small and improve mold release property and oxidation resistance and resistance to release of mold by forming a surface layer consisting of BC compound or mixture mainly containing the BC compound and C on a forming face of mold substrate.

CONSTITUTION: At least one kind of intermediate layer 3 as necessary having 0.02-1.0 μm film thickness and selected from silicon, W, Ta, Nb and AlN is provided on a forming face of mold substrate 1 bringing into contact with at least optical glass raw material. Then a surface layer 2 consisting of a BC compound or mixture mainly containing the BC compound and C and having ≥ 2wt.% B content and having 0.1-2.0 μm film thickness is formed on the intermediate layer 3 to provide a mold for forming an optical glass raw material.



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JAPANESE

[JP,05-024865,A]

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CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART EFFECT OF THE INVENTION TECHNICAL  
PROBLEM MEANS EXAMPLE DESCRIPTION OF DRAWINGS DRAWINGS

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CLAIMS

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[Claim(s)]

[Claim 1] The optical-glass component molding die characterized by forming the surface layer which consists of mixture which made the subject a boron carbide compound or a boron carbide compound, and carbon in the shaping side of the metal mold base material which contacts an optical-glass component ingredient at least.

[Claim 2] The optical-glass component molding die according to claim 1 characterized by forming the interlayer who consists of at least one sort chosen from the group which consists of silicon, a tungsten, a tantalum, a niobium, and aluminum nitride between a metal mold base material and a surface layer.

[Claim 3] The thickness of a surface layer 0.1-2.0 Optical-glass component molding die given in either claim 1 characterized by being mum, or claim 2.

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to an optical-glass component molding die.

[0002]

[Description of the Prior Art] An optical-glass component molding die presses a highly precise optical-glass component directly, fabricates it, as die materials of this optical-glass component molding die, is stable, excellent in oxidation resistance with an elevated temperature, and it is inactive to glass, a mechanical strength is high so that configuration precision may not collapse at the time of press forming, and it needs to excel in the mold-release characteristic after press forming. Furthermore, it must excel in workability and precision processing must be able to be performed easily.

[0003] Conventionally, as die materials used for the press molding die of this optical-glass component, silicon carbide (SiC) and a silicon nitride (Si<sub>3</sub>N<sub>4</sub>) are known (refer to JP,52-45613,A), and the charge of an admixture of a titanium carbide (TiC) and a metal etc. is examined further (refer to JP,59-121126,A).

[0004] Moreover, a means to use glassy carbon (amorphous carbon) as die materials, a means (refer to JP,61-281030,A) to form in the shaping side of metal mold the protective coat which consists of a diamond-like carbon thin film (diamond-like carbon), a means (refer to JP,62-207726,A) to give a carbon coat to one [ at least ] field of glass and metal mold, etc. are indicated as a means to aim at improvement in the mold-release characteristic after press forming.

[0005] Moreover, in the metal mold with which the protective coat was formed in the shaping side of metal mold, in order to prevent exfoliation of this protective coat and generating of a crack, silicon carbide or aluminum nitride is used as a metal-mold base material, and after preparing interlayers, such as metal mold (refer to JP,62-132734,A) which carried out the laminating of the film which consists of silicon carbide, and the film which consists of a nitride one by one, a nitride, or carbide, in a shaping side, the metal mold (refer to JP,61-136928,A) which prepared noble-metals layers, such as platinum, is known.

[0006]

[Problem(s) to be Solved by the Invention] However, what is satisfied with a means to prepare a protective coat in the conventional die materials and the shaping side of metal mold of all the above-mentioned conditions is not obtained. For example, when silicon carbide or a silicon nitride is used as \*\* die materials, although metal mold becomes what has a very hard and high mechanical strength, workability is inferior in it. Moreover, it has the fault that the lead (Pb) which is the constituent of an optical-glass component ingredient tends to react with an alkali element.

\*\* When the charge of an admixture of a titanium carbide and a metal is used as die materials, it is easy to react with the constituent of an optical-glass component ingredient, and it cannot be said that it is suitable.

\*\* Heating oxidation is carried out by the oxygen which remains to the shaping interior of a room, and the metal mold with which a diamond-like carbon thin film, a carbon coat, or the hard carbon film was formed has the problem that the fall of thickness, surface AREA of a shaping side, and surface type-like change arise, when shaping of long duration is presented.

\*\* When a protective coat is formed in the shaping side of metal mold with the combination of the conventional interlayer and a surface layer and long duration, for example, 1000 - 5000 shaping, is presented, produce exfoliation of a protective coat and generating of a crack.

[0007] This invention is made based on the above situations. The purpose of this invention Can fabricate the good highly precise optical-glass component of optical-character ability, and reactivity with the lead which is the constituent of an optical-glass component ingredient is small. It is in offering the optical-glass component molding die which faults, such as exfoliation of a protective coat, generating of a crack, and surface type-like change, cannot produce easily, without carrying out heating oxidation of the protective coat, even when it excels in a mold-release characteristic and shaping of long duration is presented, without an optical-glass component adhering after shaping.

[0008]

[Means for Solving the Problem] The optical-glass component molding die of this invention is characterized by forming the surface layer which consists of mixture which made the subject a boron carbide compound or a boron carbide compound, and carbon in the shaping side of the metal mold base material which contacts an optical-glass component ingredient at least.

[0009] Moreover, it is desirable that the interlayer who consists of at least one sort chosen from the group which

consists of silicon, a tungsten, a tantalum, a niobium, and aluminium nitride is formed between a metal mold base material and a surface layer.

[0010] Moreover, the thickness of a surface layer 0.1-2.0 It is desirable that it is mum.

[0011] Hereafter, the optical-glass component molding die of this invention is explained concretely.

The ingredient of a <metal mold base material> metal mold base material is excellent in thermal resistance, its degree of hardness is high, and it is needed that it is an easily processible thing. As such an ingredient, tungsten-carbide alloys, such as a WC-Co alloy, for example, "RCC-FN" (Nippon Tungsten Co., Ltd. make), the WC-nickel-Cr-Mo alloy 11, for example, "RCC-NR" (company make), and a WC-TaC-TiC alloy, for example, "RCC-L" (company make) etc., silicon carbide, a silicon nitride, stainless steel, various kinds of cermet material, etc. can be mentioned.

[0012] <Surface layer> The surface layer formed in the shaping side of a metal mold base material at least consists of mixture which made the subject a boron carbide compound or a boron carbide compound, and carbon. When forming the surface layer which consists of mixture which made a boron carbide compound and carbon the subject, it is desirable still more desirable that it is 2 % of the weight or more, and a boron content is 2 - 50 % of the weight. As the formation approach of a surface layer, magnetron sputtering vacuum deposition, ion plating vacuum deposition, etc. can be mentioned, for example. In case it forms with magnetron sputtering vacuum deposition, when forming the surface layer which consists of mixture which made a boron carbide compound and carbon the subject, using a boron carbide sintered compact as target material, what put the plate of a boron carbide sintered compact in order in fixed area (boron carbide/carbon = 0.03-0.6) can be used for the front face of a carbon target. discharge power — for example, 1 - 1.5 KW — it is — as introductory gas — for example, argon gas — using — a degree of vacuum —  $9 \times 10^{-4}$  [ for example, ] -  $2 \times 10^{-3}$  Torr and substrate temperature — for example, — It is the range of 250 - 600 \*\*. It is desirable that they are the thickness of the surface layer formed and 0.1-2 micrometers. In addition, the boron element in a surface layer may be contained in the surface layer in the state of the boron carbide compound, or may be contained as a simple substance in the carbon film. Furthermore, the surface layer may have elements contained at the time of membrane formation, such as nitrogen and an argon.

[0013] It consists of at least one sort chosen from the group which consists of silicon, a tungsten, a tantalum, a niobium, and aluminium nitride as an interlayer formed between a <interlayer> metal mold base material and a surface layer. Moreover, as an interlayer, nitrogen and carbon may contain with the above-mentioned element. As an interlayer's formation approach, magnetron sputtering vacuum deposition can be mentioned, for example, and it can carry out on conditions equivalent to the formation conditions of a surface layer. An interlayer's thickness formed is 0.02-1.0. It is desirable that it is mum.

[0014]

[Example] Hereafter, this invention is not limited by these although the example of this invention is explained.

(Example 1) a tungsten-carbide alloy (WC-Co alloy) "RCC-FN" (Nippon Tungsten Co., Ltd. make) with a diameter [ of 20mm ], and a thickness of 6mm — using — radius of curvature — respectively — 46mm — and — The punch and female mold which have the shaping side of the shape of a concave surface which is 200mm were produced, and these types of shaping side was ground to the mirror plane with the overly detailed diamond abrasive grain.

[0015] Subsequently, as shown in drawing 1, the surface layer 2 which consists of a boron carbide compound was formed in each type 1 of shaping side, and the optical-glass component molding die (sample No.1-6 of the after-mentioned table 1) of this invention was manufactured. Formation of a surface layer 2 was performed with direct-current magnetron sputtering vacuum deposition according to the following conditions.

Target: B4 C sintering target "NPB-1" (Nippon Tungsten Co., Ltd. make)

Sputter conditions: Direct-current magnetron sputtering discharge power: 1.0kW installation gas: Argon gas (about [ degree of vacuum ]  $9 \times 10^{-4}$  Torr)

Substrate heating temperature: In addition, existence of a boron carbide compound was checked by X-ray diffraction evaluation, and 400 degrees C of contents of a boron compound were presumed by the X-ray microanalyser (XMA). Place which observed the condition of the formed surface layer with the optical microscope, and measured the surface roughness (it is also called an "RMS value" mean square granularity and the following.) of the shaping side at that time It was 100A or less (100-80A).

[0016] Each of an optical-glass component molding die (sample No.1-6) was set to the press-forming machine shown in drawing 3. In this drawing, 4 and 5 are optical-glass component molding dice, 4 is a punch and 5 is female mold. The heating heater for punches and 7 are lead oxide system optical glass (heavy Flint system glass) with which the piston cylinder for punches and 9 are optical-glass component ingredients, and the piston cylinder for female mold and 10 consist [ the heating heater for female mold, and 8 ] of 70 % of the weight (PbO) of lead oxide, 27 % of the weight (SiO<sub>2</sub>) of silicas, and 3 % of the weight of minor constituents in this example, and 6 used the massive object with a radius of 10mm processed spherically. As for the output port of the optical-glass component from which 11 is obtained with the fixture for supply of the optical-glass component ingredient 10, and 12 is obtained by press forming, and 13, the preheating furnace of the optical-glass component ingredient 10 and 14 are coverings.

[0017] Supply arrangement of the optical-glass component ingredient 10 heated at the preheating furnace 13 is carried out between the punch 4 currently held at 520 degree C, and female mold 5, and they are the inside of nitrogen-gas-atmosphere mind, and about 40kg/cm<sup>2</sup>. It holds for 2 minutes by press \*\*, and is the mold of the upper and lower sides in the condition as it is after that. It cooled to 300 degrees C and the optical-glass component by which press forming was carried out was taken out from output port 12. The forming cycle of an

optical-glass component is completed by the above actuation. In addition, the fabricated optical-glass component was taken out easily, without adhering to the shaping side of a mold, and the mold-release characteristic was very good. Moreover, in the following examples, the mold-release characteristic was good similarly.

[0018] Place which removed a punch 4 and female mold 5 from the press-forming machine, observed the surface state of a shaping side with the optical microscope, and measured the surface roughness at that time (RMS value) after repeating the above process and carrying out 3000 times It is 400A or less and compares shaping before. Although degradation of less than 300A was seen, there is no problem on lens moldability ability, and the lens which was excellent in the optical property was obtained.

[0019] (Example 2) Thickness is 0.05 micrometers and 2.3 to the shaping side of a metal mold base material like an example 1, respectively. The surface layer of mum was formed and the optical-glass component molding die (sample No.7-8 of the after-mentioned table 1) of this invention was manufactured. Like an example 1, when the surface roughness (RMS value) of a shaping side was measured, it is thickness. In the case of 2.3 micrometers (sample No.8), it is larger than 90 - 200 \*\* and an example 1, and an RMS value locally There were 500-1000A and a large part.

[0020] When each of an optical-glass component molding die (sample No.7-8) was set to the press-forming machine, and the forming cycle of an optical-glass component was repeated like the example 1, were carried out 3000 times and thickness was 0.05 micrometers (sample No.7), exfoliation of a surface layer was produced in part near the periphery of a shaping side. Thickness of the above result to a surface layer 0.1-2.0 It can be said that it is suitable that it is in the range of mum.

[0021] (Example 3) an example 1 — the same — carrying out — radius of curvature — respectively — 46mm — and — The punch and female mold which have the shaping side of the shape of a concave surface which is 200mm were produced, and these types of shaping side was ground to the mirror plane with the overly detailed diamond abrasive grain.

[0022] Subsequently, as shown in the drawing 2 (\*\*), the interlayer 3 who consists of silicon (sample No.9), a tungsten (sample No.10), a tantalum (sample No.11), and aluminium nitride (sample No.12) was formed in the shaping side of a mold 1, respectively. As a target ingredient, except having used each ingredient of silicon, a tungsten, a tantalum, and aluminium nitride, an interlayer's 3 formation is the same conditions as formation of the surface layer in an example 1, and was performed with direct-current magnetron sputtering vacuum deposition. The formed thickness is in 0.05 micrometers and a tantalum layer in 0.02 micrometers and a tungsten layer at a silicon layer, as shown in Table 1. In 0.1 micrometers and an aluminium nitride layer It is 0.5 micrometers.

[0023] Subsequently, as shown in the drawing 2 (\*\*), the surface layer 2 of 1 micrometer of thickness which consists of a boron carbide compound like an example 1 was formed on the shaping side in which the interlayer 3 was formed, and the optical-glass component molding die (sample No.9-12 of the after-mentioned table 1) of this invention was manufactured. Like the example 1, when the surface roughness (RMS value) of a shaping side was measured, it was 80-150 \*\* and the optical property top was good. In addition, thickness When the surface layer of 1 micrometer of thickness which consists of a boron carbide compound was formed after forming the interlayer exceeding 1.0 micrometers, the surface roughness (RMS value) of a shaping side had a part locally exceeding 500A. The above result to an interlayer's thickness is 0.02-1.0. It can be said that it is suitable that it is in the range of mum.

[0024] Each of an optical-glass component molding die (sample No.9-12) is set to a press-forming machine like an example 1. After repeating the forming cycle of an optical-glass component and carrying out 3000 times, a punch 4 and female mold 5 are removed from a press-forming machine. Place which measured the surface roughness (RMS value) of a shaping side It is 300A or less and compares shaping before. Only by degradation of less than 150A arising, it was satisfactory in any way on lens moldability ability.

[0025] (Example 4) an example 1 — the same — carrying out — radius of curvature — respectively — 46mm — and — The punch and female mold which have the shaping side of the shape of a concave surface which is 200mm were produced, and these types of shaping side was ground to the mirror plane with the overly detailed diamond abrasive grain.

[0026] Subsequently, the surface layer which consists of mixture which made a boron carbide compound and carbon the subject was formed in each type of shaping side, and the optical-glass component molding die (sample No.13-16 of the after-mentioned table 1) of this invention was manufactured. Formation of a surface layer was performed on the same conditions as an example 1 except having used the target shown below. Target: What has arranged the sintering plate of a boron carbide compound with a thickness of 1mm by fixed surface ratio on the front face of a carbon target "IG-510" (Toyo Tanso make). However, the surface ratio of each carbon target and a boron carbide compound is as follows.

Surface ratio (sample No.13) Boron carbide/carbon = 0.03 (sample No.14) Boron carbide/carbon = 0.08 (sample No.15) Boron carbide/carbon = 0.25 (sample No.16) Boron carbide/carbon = like 0.45 examples 1, when the surface roughness (RMS value) of a shaping side was measured, it was 100-70A and was good.

[0027] Place which measured the surface roughness (RMS value) of a shaping side after having set each of an optical-glass component molding die (sample No.13-16) to the press-forming machine, repeating the forming cycle of an optical-glass component like the example 1 and carrying out 3000 times It is 450A or less and compares shaping before. Only by degradation of less than 350A arising, it was satisfactory in any way on lens moldability ability.

[0028] (Example 1 of a comparison) A punch and female mold were produced using the WC-Co alloy "RCC-FN", like

the example 1, the titanium nitride layer usually used for the shaping side of these metal mold base materials as a protective layer of a plastics molding die was formed with ion plating vacuum deposition so that thickness might be set to 1 micrometer, and the molding die (sample No.17) was manufactured. Like the example 1, when the surface roughness (RMS value) of a shaping side was measured, it was 100 or less A and was in the good condition optically.

[0029] When the molding die (sample No.17) was set to the press-forming machine, and the forming cycle of an optical-glass component was repeated like the example 1 and having been carried out 3000 times, adhesion of the foreign matter to a shaping side was accepted, and exfoliation was further produced in a part of titanium nitride layer. For this reason, the field configuration of a shaping lens deteriorated, and the mold-release characteristic from the metal mold of a shaping lens fell, and it became a fabrication top problem.

[0030] The measured value of the surface roughness (RMS value) in each example and evaluation of a mold-release characteristic are shown in Table 1.

[0031]

[Table 1]

	試料 番号	中間層		表面層		RMS値(Å)		離型性
		物質	膜厚 (μm)	ホウ素含有量 (重量%)	膜厚 (μm)	成形前	3000回 成形後	
実施例 1	1	—	—	約70~80	0.1	100 ~ 80	400 以下	良 好
	2	—	—	約70~80	0.5			
	3	—	—	約70~80	0.7			
	4	—	—	約70~80	1.0			
	5	—	—	約70~80	1.5			
	6	—	—	約70~80	2.0			
実施例 2	7	—	—	約70~80	0.05	100 ~70	一部 膜剝離	やや 困難
	8	—	—	約70~80	2.3	200 ~90	局部的に 500 以上	良 好
実施例 3	9	シリコン	0.02	約70~80	1.0	150 ~ 80	300 以下	良 好
	10	タングス テン	0.05	約70~80	1.0			
	11	タンタル	0.1	約70~80	1.0			
	12	窒化アル ミニウム	0.5	約70~80	1.0			
実施例 4	13	—	—	約5	1.3	100 ~ 70	450 以下	良 好
	14	—	—	約10	1.3			
	15	—	—	約30	1.3			
	16	—	—	約50	1.3			
比較例 1	17	—	—	0	1.0	100 ~ 60	膜剝離 異物付着 発生	不 良

[0032]

[Effect of the Invention] As mentioned above, the optical-glass component molding die of this invention is stable, and is excellent in oxidation resistance and workability with an elevated temperature, and precision processing is easy for it. And to an optical-glass component ingredient, the shaping side is inactive, excellent in a mold-release characteristic after shaping, and it has sufficient endurance that it is hard to produce faults, such as exfoliation of a protective coat, generating of a crack, and surface type-like change, without carrying out heating oxidation of the protective coat, even when press forming of long duration is presented. For this reason, after carrying out press forming 3000 times, a highly precise glass component moldings can be obtained. In addition, even if it used the cermet which uses each of a titanium nitride (TiN), a titanium carbide (TiC), chromium carbide (Cr<sub>3</sub>C<sub>2</sub>), and an alumina (aluminum 2O<sub>3</sub>) as a principal component instead of the tungsten carbide (WC), silicon carbide (SiC), chrome oxide (CrO<sub>2</sub>), etc. as a metal mold base material, the life of a mold was able to be raised similarly. Moreover, it is

also possible to obtain mold goods by the optical-glass component molding die of this invention by using the inorganic substances and macromolecule resin other than glass as a molding material.

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TECHNICAL FIELD

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[Industrial Application] This invention relates to an optical-glass component molding die.

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PRIOR ART

[Description of the Prior Art] An optical-glass component molding die presses a highly precise optical-glass component directly, fabricates it, as die materials of this optical-glass component molding die, is stable, excellent in oxidation resistance with an elevated temperature, and it is inactive to glass, a mechanical strength is high so that configuration precision may not collapse at the time of press forming, and it needs to excel in the mold-release characteristic after press forming. Furthermore, it must excel in workability and precision processing must be able to be performed easily.

[0003] Conventionally, as die materials used for the press molding die of this optical-glass component, silicon carbide (SiC) and a silicon nitride (Si<sub>3</sub>N<sub>4</sub>) are known (refer to JP,52-45613,A), and the charge of an admixture of a titanium carbide (TiC) and a metal etc. is examined further (refer to JP,59-121126,A).

[0004] Moreover, a means to use glassy carbon (amorphous carbon) as die materials, a means (refer to JP,61-281030,A) to form in the shaping side of metal mold the protective coat which consists of a diamond-like carbon thin film (diamond-like carbon), a means (refer to JP,62-207726,A) to give a carbon coat to one [ at least ] field of glass and metal mold, etc. are indicated as a means to aim at improvement in the mold-release characteristic after press forming.

[0005] Moreover, in the metal mold with which the protective coat was formed in the shaping side of metal mold, in order to prevent exfoliation of this protective coat and generating of a crack, silicon carbide or aluminum nitride is used as a metal-mold base material, and after preparing interlayers, such as metal mold (refer to JP,62-132734,A) which carried out the laminating of the film which consists of silicon carbide, and the film which consists of a nitride one by one, a nitride, or carbide, in a shaping side, the metal mold (refer to JP,61-136928,A) which prepared noble-metals layers, such as platinum, is known.

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EFFECT OF THE INVENTION

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[Effect of the Invention] As mentioned above, the optical-glass component molding die of this invention is stable, and is excellent in oxidation resistance and workability with an elevated temperature, and precision processing is easy for it. And to an optical-glass component ingredient, the shaping side is inactive, excellent in a mold-release characteristic after shaping, and it has sufficient endurance that it is hard to produce nonconformities, such as exfoliation of a protective coat, generating of a crack, and surface type-like change, without carrying out heating oxidation of the protective coat, even when press forming of long duration is presented. For this reason, after carrying out press forming 3000 times, the glass component moldings of high degree of accuracy can be obtained. In addition, even if it used the cermet which uses each of a titanium nitride (TiN), a titanium carbide (TiC), chromium carbide (Cr<sub>3</sub>C<sub>2</sub>), and an alumina (aluminum 2O<sub>3</sub>) as a principal component instead of the tungsten carbide (WC), silicon carbide (SiC), chrome oxide (CrO<sub>2</sub>), etc. as a metal mold base material, the life of a mold was able to be raised similarly. Moreover, it is also possible to obtain mold goods by the optical-glass component molding die of this invention by using the inorganic substances and macromolecule resin other than glass as a molding material.

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TECHNICAL PROBLEM

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[Problem(s) to be Solved by the Invention] However, what is satisfied with a means to prepare a protective coat in the conventional die materials and the shaping side of metal mold of all the above-mentioned conditions is not obtained. For example, when silicon carbide or a silicon nitride is used as \*\* die materials, although metal mold becomes what has a very hard and high mechanical strength, workability is inferior in it. Moreover, it has the fault that the lead (Pb) which is the constituent of an optical-glass component ingredient tends to react with an alkali element.

\*\* When the charge of an admixture of a titanium carbide and a metal is used as die materials, it is easy to react with the constituent of an optical-glass component ingredient, and it cannot be said that it is suitable.

\*\* Heating oxidation is carried out by the oxygen which remains to the shaping interior of a room, and the metal mold with which a diamond-like carbon thin film, a carbon coat, or the hard carbon film was formed has the problem that lowering of thickness, surface AREA of a shaping side, and surface type-like change arise, when shaping of long duration is presented.

\*\* When a protective coat is formed in the shaping side of metal mold with the combination of the conventional interlayer and a surface layer and long duration, for example, 1000 - 5000 shaping, is presented, produce exfoliation of a protective coat and generating of a crack.

[0007] This invention is made based on the above situations. The object of this invention Can fabricate the good highly precise optical-glass component of optical-character ability, and reactivity with the lead which is the constituent of an optical-glass component ingredient is small. It is in offering the optical-glass component molding die which nonconformities, such as exfoliation of a protective coat, generating of a crack, and surface type-like change, cannot produce easily, without carrying out heating oxidation of the protective coat, even when it excels in a mold-release characteristic and shaping of long duration is presented, without an optical-glass component adhering after shaping.

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MEANS

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[Means for Solving the Problem] The optical-glass component molding die of this invention is characterized by forming the surface layer which consists of mixture which made the subject a boron carbide compound or a boron carbide compound, and carbon in the shaping side of the metal mold base material which contacts an optical-glass component ingredient at least.

[0009] Moreover, it is desirable that the interlayer who consists of at least one sort chosen from the group which consists of silicon, a tungsten, a tantalum, a niobium, and aluminium nitride is formed between a metal mold base material and a surface layer.

[0010] Moreover, the thickness of a surface layer 0.1-2.0 It is desirable that it is mum.

[0011] Hereafter, the optical-glass component molding die of this invention is explained concretely.

The ingredient of a <metal mold base material> metal mold base material is excellent in thermal resistance, its degree of hardness is high, and it is needed that it is an easily processible thing. As such an ingredient, tungsten-carbide alloys, such as a WC-Co alloy, for example, "RCC-FN" (Nippon Tungsten Co., Ltd. make), the WC-nickel-Cr-Mo alloy 11, for example, "RCC-NR" (company make), and a WC-TaC-TiC alloy, for example, "RCC-L" (company make) etc., silicon carbide, a silicon night light, stainless steel, various kinds of cermet material, etc. can be mentioned.

[0012] <Surface layer> The surface layer formed in the shaping side of a metal mold base material at least consists of mixture which made the subject a boron carbide compound or a boron carbide compound, and carbon. When forming the surface layer which consists of mixture which made a boron carbide compound and carbon the subject, it is desirable still more desirable that it is 2 % of the weight or more, and a boron content is 2 - 50 % of the weight. As the formation approach of a surface layer, magnetron sputtering vacuum deposition, ion plating vacuum deposition, etc. can be mentioned, for example. In case it forms with magnetron sputtering vacuum deposition, when forming the surface layer which consists of mixture which made a boron carbide compound and carbon the subject, using a boron carbide sintered compact as target material, what put the plate of a boron carbide sintered compact in order in fixed area (boron carbide/carbon = 0.03-0.6) can be used for the front face of a carbon target. discharge power — for example, 1 - 1.5 KW — it is — as introductory gas — for example, argon gas — using — a degree of vacuum —  $9 \times 10^{-4}$  [ for example, ] -  $2 \times 10^{-3}$  Torr and substrate temperature — for example, — It is the range of 250 - 600 \*\*. It is desirable that they are the thickness of the surface layer formed and 0.1-2 micrometers. In addition, the boron element in a surface layer may be contained in the surface layer in the state of the boron carbide compound, or may be contained as a simple substance in the carbon film. Furthermore, the surface layer may have elements contained at the time of membrane formation, such as nitrogen and an argon.

[0013] It consists of at least one sort chosen from the group which consists of silicon, a tungsten, a tantalum, a niobium, and aluminium nitride as an interlayer formed between a <interlayer> metal mold base material and a surface layer. Moreover, as an interlayer, nitrogen and carbon may contain with the above-mentioned element. As an interlayer's formation approach, magnetron sputtering vacuum deposition can be mentioned, for example, and it can carry out on conditions equivalent to the formation conditions of a surface layer. An interlayer's thickness formed is 0.02-1.0. It is desirable that it is mum.

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[Translation done.]

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## EXAMPLE

[Example] Hereafter, this invention is not limited by these although the example of this invention is explained. (Example 1) a tungsten-carbide alloy (WC-Co alloy) "RCC-FN" (Nippon Tungsten Co., Ltd. make) with a diameter [ of 20mm ], and a thickness of 6mm — using — radius of curvature — respectively — 46mm — and — The punch and female mold which have the shaping side of the shape of a concave surface which is 200mm were produced, and these types of shaping side was ground to the mirror plane with the overly detailed diamond abrasive grain. [0015] Subsequently, as shown in drawing 1 , the surface layer 2 which consists of a boron carbide compound was formed in each type 1 of shaping side, and the optical-glass component molding die (sample No.1-6 of the after-mentioned table 1) of this invention was manufactured. Formation of a surface layer 2 was performed with direct-current magnetron sputtering vacuum deposition according to the following conditions.

Target: B4 C sintering target "NPB-1" (Nippon Tungsten Co., Ltd. make)

Sputter conditions: Direct-current magnetron sputtering discharge power: 1.0kW installation gas: Argon gas (about [ degree of vacuum ]  $9 \times 10^{-4}$  Torr)

Substrate heating temperature: In addition, existence of a boron carbide compound was checked by X-ray diffraction assessment, and 400 degrees C of contents of a boron compound were presumed by the X-ray microanalyser (XMA). Place which observed the condition of the formed surface layer with the optical microscope, and measured the surface roughness (it is also called an "RMS value" mean square granularity and the following.) of the shaping side at that time It was 100A or less (100-80A).

[0016] Each of an optical-glass component molding die (sample No.1-6) was set to the press-forming machine shown in drawing 3 . In this drawing, 4 and 5 are optical-glass component molding dice, 4 is a punch and 5 is female mold. The heating heater for punches and 7 are lead oxide system optical glass (heavy Flint system glass) with which the piston cylinder for punches and 9 are optical-glass component ingredients, and the piston cylinder for female mold and 10 consist [ the heating heater for female mold, and 8 ] of 70 % of the weight (PbO) of lead oxide, 27 % of the weight (SiO<sub>2</sub>) of silicas, and 3 % of the weight of minor constituents in this example, and 6 used the massive object with a radius of 10mm processed spherically. As for the output port of the optical-glass component from which 11 is obtained with the fixture for supply of the optical-glass component ingredient 10, and 12 is obtained by press forming, and 13, the preheating furnace of the optical-glass component ingredient 10 and 14 are coverings.

[0017] Supply arrangement of the optical-glass component ingredient 10 heated at the preheating furnace 13 is carried out between the punch 4 currently held at 520 degree C, and female mold 5, and they are the inside of nitrogen-gas-atmosphere mind, and about 40kg/cm<sup>2</sup>. It holds for 2 minutes by press \*\*, and is the mold of the upper and lower sides in the condition as it is after that. It cooled to 300 degrees C and the optical-glass component by which press forming was carried out was taken out from output port 12. The forming cycle of an optical-glass component is completed by the above actuation. In addition, the fabricated optical-glass component was taken out easily, without adhering to the shaping side of a mold, and the mold-release characteristic was very good. Moreover, in the following examples, the mold-release characteristic was good similarly.

[0018] Place which removed a punch 4 and female mold 5 from the press-forming machine, observed the surface state of a shaping side with the optical microscope, and measured the surface roughness at that time (RMS value) after repeating the above process and carrying out 3000 times It is 400A or less and compares shaping before. Although degradation of less than 300A was seen, there is no problem on lens moldability ability, and the lens which was excellent in the optical property was obtained.

[0019] (Example 2) Thickness is 0.05 micrometers and 2.3 to the shaping side of a metal mold base material like an example 1, respectively. The surface layer of mum was formed and the optical-glass component molding die (sample No.7-8 of the after-mentioned table 1) of this invention was manufactured. Like an example 1, when the surface roughness (RMS value) of a shaping side was measured, it is thickness. In the case of 2.3 micrometers (sample No.8), it is larger than 90 - 200 \*\* and an example 1, and an RMS value locally There were 500-1000A and a large part.

[0020] When each of an optical-glass component molding die (sample No.7-8) was set to the press-forming machine, and the forming cycle of an optical-glass component was repeated like the example 1, were carried out 3000 times and thickness was 0.05 micrometers (sample No.7), exfoliation of a surface layer was produced in part near the periphery of a shaping side. Thickness of the above result to a surface layer 0.1-2.0 It can be said that it is suitable that it is in the range of mum.

[0021] (Example 3) an example 1 — the same — carrying out — radius of curvature — respectively — 46mm —

and — The punch and female mold which have the shaping side of the shape of a concave surface which is 200mm were produced, and these types of shaping side was ground to the mirror plane with the overly detailed diamond abrasive grain.

[0022] Subsequently, as shown in the drawing 2 (\*\*), the interlayer 3 who consists of silicon (sample No.9), a tungsten (sample No.10), a tantalum (sample No.11), and aluminium nitride (sample No.12) was formed in the shaping side of a mold 1, respectively. As a target ingredient, except having used each ingredient of silicon, a tungsten, a tantalum, and aluminium nitride, an interlayer's 3 formation is the same conditions as formation of the surface layer in an example 1, and was performed with direct-current magnetron sputtering vacuum deposition. The formed thickness is in 0.05 micrometers and a tantalum layer in 0.02 micrometers and a tungsten layer at a silicon layer, as shown in a table 1. In 0.1 micrometers and an aluminium nitride layer It is 0.5 micrometers.

[0023] Subsequently, as shown in the drawing 2 (\*\*), the surface layer 2 of 1 micrometer of thickness which consists of a boron carbide compound like an example 1 was formed on the shaping side in which the interlayer 3 was formed, and the optical-glass component molding die (sample No.9-12 of the after-mentioned table 1) of this invention was manufactured. Like the example 1, when the surface roughness (RMS value) of a shaping side was measured, it was 80-150 \*\* and the optical property top was good. In addition, thickness When the surface layer of 1 micrometer of thickness which consists of a boron carbide compound was formed after forming the interlayer exceeding 1.0 micrometers, the surface roughness (RMS value) of a shaping side had a part locally exceeding 500A. The above result to an interlayer's thickness is 0.02-1.0. It can be said that it is suitable that it is in the range of mum.

[0024] Each of an optical-glass component molding die (sample No.9-12) is set to a press-forming machine like an example 1. After repeating the forming cycle of an optical-glass component and carrying out 3000 times, a punch 4 and female mold 5 are removed from a press-forming machine. Place which measured the surface roughness (RMS value) of a shaping side It is 300A or less and compares shaping before. Only by degradation of less than 150A arising, it was satisfactory in any way on lens moldability ability.

[0025] (Example 4) an example 1 — the same — carrying out — radius of curvature — respectively — 46mm — and — The punch and female mold which have the shaping side of the shape of a concave surface which is 200mm were produced, and these types of shaping side was ground to the mirror plane with the overly detailed diamond abrasive grain.

[0026] Subsequently, the surface layer which consists of mixture which made a boron carbide compound and carbon the subject was formed in each type of shaping side, and the optical-glass component molding die (sample No.13-16 of the after-mentioned table 1) of this invention was manufactured. Formation of a surface layer was performed on the same conditions as an example 1 except having used the target shown below. Target: What has arranged the sintering plate of a boron carbide compound with a thickness of 1mm by fixed surface ratio on the front face of a carbon target "IG-510" (Toyo Tanso make). However, the surface ratio of each carbon target and a boron carbide compound is as follows.

Surface ratio (sample No.13) Boron carbide/carbon = 0.03 (sample No.14) Boron carbide/carbon = 0.08 (sample No.15) Boron carbide/carbon = 0.25 (sample No.16) Boron carbide/carbon = like 0.45 examples 1, when the surface roughness (RMS value) of a shaping side was measured, it was 100-70A and was good.

[0027] Place which measured the surface roughness (RMS value) of a shaping side after having set each of an optical-glass component molding die (sample No.13-16) to the press-forming machine, repeating the forming cycle of an optical-glass component like the example 1 and carrying out 3000 times It is 450A or less and compares shaping before. Only by degradation of less than 350A arising, it was satisfactory in any way on lens moldability ability.

[0028] (Example 1 of a comparison) A punch and female mold were produced using the WC-Co alloy "RCC-FN", like the example 1, the titanium nitride layer usually used for the shaping side of these metal mold base materials as a protective layer of a plastics molding die was formed with ion plating vacuum deposition so that thickness might be set to 1 micrometer, and the molding die (sample No.17) was manufactured. Like the example 1, when the surface roughness (RMS value) of a shaping side was measured, it was 100 or less A and was in the good condition optically.

[0029] When the molding die (sample No.17) was set to the press-forming machine, and the forming cycle of an optical-glass component was repeated like the example 1 and having been carried out 3000 times, adhesion of the foreign matter to a shaping side was accepted, and exfoliation was further produced in a part of titanium nitride layer. For this reason, the field configuration of a shaping lens deteriorated, and the mold-release characteristic from the metal mold of a shaping lens fell, and it became a fabricating-operation top problem.

[0030] The measured value of the surface roughness (RMS value) in each example and assessment of a mold-release characteristic are shown in a table 1.

[0031]

[A table 1]

	試料番号	中間層		表面層		RMS値 (Å)		離型性
		物質	膜厚 (μm)	ホウ素含有量 (重量%)	膜厚 (μm)	成形前	3000回成形後	
実施例 1	1	-	-	約70~80	0.1	100 ~ 80	400 以下	良好
	2	-	-	約70~80	0.5			
	3	-	-	約70~80	0.7			
	4	-	-	約70~80	1.0			
	5	-	-	約70~80	1.5			
	6	-	-	約70~80	2.0			
実施例 2	7	-	-	約70~80	0.05	100 ~70	一部 膜剥離	やや 困難
	8	-	-	約70~80	2.3	200 ~90	局部的に 500 以上	良好
実施例 3	9	シリコン	0.02	約70~80	1.0	150 ~ 80	300 以下	良好
	10	タンゲステン	0.05	約70~80	1.0			
	11	タンタル	0.1	約70~80	1.0			
	12	窒化アルミニウム	0.5	約70~80	1.0			
実施例 4	13	-	-	約5	1.3	100 ~ 70	450 以下	良好
	14	-	-	約10	1.3			
	15	-	-	約30	1.3			
	16	-	-	約50	1.3			
比較例 1	17	-	-	0	1.0	100 ~ 60	膜剥離 異物付着 発生	不良

[Translation done.]

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DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] It is the sectional view for explanation showing an example of the optical-glass component molding die of this invention.

[Drawing 2] It is the sectional view for explanation showing other examples of the optical-glass component molding die of this invention.

[Drawing 3] It is the explanatory view showing the press-forming machine with which the optical-glass component molding die of this invention was set.

[Description of Notations]

1 Mold 2 Surface Layer

3 Interlayer 4 Punch

5 Female Mold 6 Punch Heating Heater

7 Female Mold Heating Heater 8 Piston Cylinder for Punches

9 Piston Cylinder for Female Mold 10 Optical-Glass Component Ingredient

11 Fixture for Supply 12 Output Port

13 Preheating Furnace 14 Covering

15 Metal Mold Base Material

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[Translation done.]

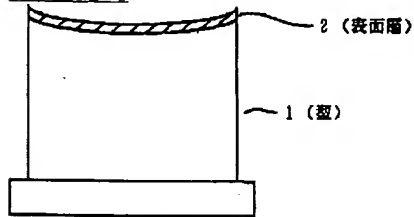
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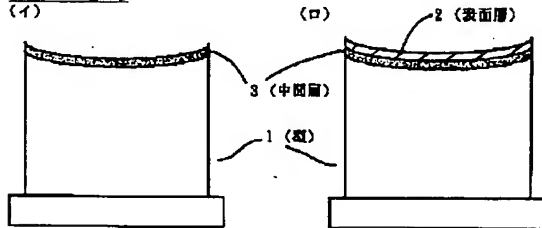
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## DRAWINGS

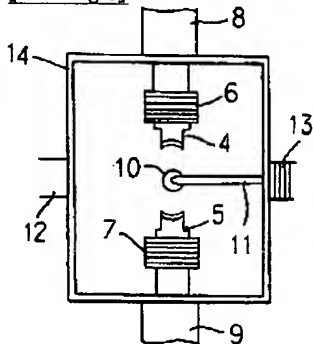
[Drawing 1]



[Drawing 2]



[Drawing 3]



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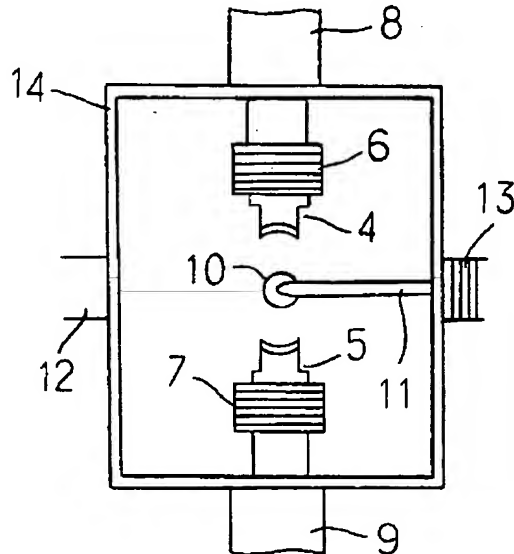
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(54)【発明の名称】 光学ガラス素子成形用金型

## (57)【要約】

【目的】 光学性能のよい高精度な光学ガラス素子を成形することができ、光学ガラス素子材料の構成成分である鉛との反応性が小さく、成形後において光学ガラス素子が付着することなく離型性に優れ、かつ長時間の成形に供した場合でも保護膜が加熱酸化されることなく、保護膜の剥離、クラックの発生、表面形状の変化などの不具合が生じにくい光学ガラス素子成形用金型を提供することにある。

【構成】 本発明の光学ガラス素子成形用金型は、少なくとも光学ガラス素子材料と接触する金型基材の成形面に、炭化ホウ素化合物または炭化ホウ素化合物と炭素を主体とした混合物からなる表面層が形成されていることを特徴とする。また、金型基材と表面層との間に、シリコン、タングステン、タンタル、ニオブウムおよび窒化アルミニウムよりなる群から選ばれた少なくとも1種からなる中間層が形成されていることが好ましい。



## 【特許請求の範囲】

【請求項1】 少なくとも光学ガラス素子材料と接触する金型基材の成形面に、炭化ホウ素化合物または炭化ホウ素化合物と炭素を主体とした混合物からなる表面層が形成されていることを特徴とする光学ガラス素子成形用金型。

【請求項2】 金型基材と表面層との間に、シリコン、タングステン、タンタル、ニオブウムおよび窒化アルミニウムよりなる群から選ばれた少なくとも1種からなる中間層が形成されていることを特徴とする請求項1に記載の光学ガラス素子成形用金型。

【請求項3】 表面層の厚さが  $0.1 \sim 2.0 \mu\text{m}$  であることを特徴とする請求項1または請求項2のいずれかに記載の光学ガラス素子成形用金型。

## 【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、光学ガラス素子成形用金型に関する。

【0002】

【従来の技術】光学ガラス素子成形用金型は、高精度な光学ガラス素子を直接プレスして成形するものであり、この光学ガラス素子成形用金型の型材料としては、高温でも安定で、耐酸化性に優れ、ガラスに対して不活性であり、プレス成形時に形状精度が崩れないよう機械的強度が高く、プレス成形後の離型性に優れたものであることが必要である。更に、加工性に優れ精密加工が容易にできるものでなければならない。

【0003】従来、斯かる光学ガラス素子のプレス成形用金型に用いられる型材料として、例えばシリコンカーバイド (SiC) やシリコンナイトライト (Si, N) が知られており (特開昭52-45613号公報参照)、更にチタンカーバイド (TiC) と金属の混合材料なども検討されている (特開昭59-121126号公報参照)。

【0004】また、プレス成形後の離型性の向上を図る手段として、型材料としてガラス状炭素 (無定形カーボン) を用いる手段、金型の成形面にダイヤモンド状炭素薄膜 (ダイヤモンドライクカーボン) からなる保護膜を形成する手段 (特開昭61-281030号公報参照)、ガラスと金型の少なくとも一方の面に炭素コートを施す手段 (特開昭62-207726号公報参照) などが開示されている。

【0005】また、金型の成形面に保護膜が形成された金型において、この保護膜の剥離やクラックの発生を防止するために、金型基材としてシリコンカーバイドまたは窒化アルミニウムを用い、成形面にシリコンカーバイドからなる膜と窒化物からなる膜を順次積層した金型 (特開昭62-132734号公報参照)、窒化物あるいは炭化物などの中間層を設けた後白金などの貴金属層を設けた金型 (特開昭61-136928号公報参照) などが知られてい

る。

【0006】

【発明が解決しようとする課題】しかしながら、従来の型材料、および金型の成形面に保護膜を設ける手段では、前述の条件を全て満足するものは得られていない。例えば、

① 型材料としてシリコンカーバイドまたはシリコンナイトライトを用いた場合においては、金型は極めて硬くて機械的強度が高いものとなるが加工性が劣る。また、光学ガラス素子材料の構成成分である鉛 (Pb) がアルカリ元素と反応しやすいという欠点を有している。

② 型材料としてチタンカーバイドと金属の混合材料を用いた場合においても、光学ガラス素子材料の構成成分と反応しやすく、適当であるとはいえない。

③ ダイヤモンド状炭素薄膜、炭素コートまたは硬質炭素膜が形成された金型は、長時間の成形に供した場合、成形室内に残留する酸素により、加熱酸化され、膜厚の低下、成形面の表面アレ、表面形状の変化が生じる、という問題がある。

④ 従来の中間層と表面層の組合せにより金型の成形面に保護膜を形成する場合でも、長時間例えば1000~5000回の成形に供した場合、保護膜の剥離やクラックの発生を生じる。

【0007】本発明は以上のような事情に基いてなされたものであって、本発明の目的は、光学性能のよい高精度な光学ガラス素子を成形することができ、光学ガラス素子材料の構成成分である鉛との反応性が小さく、成形後において光学ガラス素子が付着することなく離型性に優れ、かつ長時間の成形に供した場合でも保護膜が加熱酸化されることなく、保護膜の剥離、クラックの発生、表面形状の変化などの不具合が生じにくい光学ガラス素子成形用金型を提供することにある。

【0008】

【課題を解決するための手段】本発明の光学ガラス素子成形用金型は、少なくとも光学ガラス素子材料と接触する金型基材の成形面に、炭化ホウ素化合物または炭化ホウ素化合物と炭素を主体とした混合物からなる表面層が形成されていることを特徴とする。

【0009】また、金型基材と表面層との間に、シリコン、タングステン、タンタル、ニオブウムおよび窒化アルミニウムよりなる群から選ばれた少なくとも1種からなる中間層が形成されていることが好ましい。

【0010】また、表面層の厚さが  $0.1 \sim 2.0 \mu\text{m}$  であることが好ましい。

【0011】以下、本発明の光学ガラス素子成形用金型について具体的に説明する。

<金型基材>金型基材の材料は、耐熱性に優れ、硬度が高く、容易に加工できるものであることが必要とされる。このような材料としては、WC-Co合金例えば「RCC-FN」 (日本タングステン社製)、WC-N

i-Cr-Mo合金例えば「RCC-NR11」(同社製)、WC-TaC-TiC合金例えば「RCC-L」(同社製)などのタングステンカーバイド合金、シリコンカーバイド、シリコンナイトライド、ステンレス鋼、各種のサーメット材などを挙げることができる。

【0012】<表面層>少なくとも金型基材の成形面に形成される表面層は、炭化ホウ素化合物または炭化ホウ素化合物と炭素を主体とした混合物からなるものである。炭化ホウ素化合物と炭素を主体とした混合物からなる表面層を形成する場合、ホウ素含有量は2重量%以上であることが好ましく、更に好ましくは2~50重量%である。表面層の形成方法としては、例えばマグネトロンスパッタ蒸着法、イオンブレーティング蒸着法などを挙げることができる。マグネトロンスパッタ蒸着法により形成する際において、ターゲット材として炭化ホウ素焼結体を用い、また炭化ホウ素化合物と炭素を主体とした混合物からなる表面層を形成する場合には、炭素ターゲットの表面に炭化ホウ素焼結体の板材を一定面積(炭化ホウ素/炭素=0.03~0.6)で並べたものを用いることができる。放電電力は例えば1~1.5 KWであり、導入ガスとしては例えばアルゴンガスを用い、真空度は例えば $9 \times 10^{-4}$  ~  $2 \times 10^{-3}$  Torr、基板温度は例えば250~600℃の範囲である。形成される表面層の膜厚は、0.1~2 μmであることが好ましい。なお、表面層におけるホウ素元素は、炭化ホウ素化合物の状態では表面層に含有されていてもよく、あるいは炭素膜中に単体として含有されていてもよい。さらに、表面層は、成膜時に含有される窒素、アルゴンなどの元素を有していてもよい。

【0013】<中間層>金型基材と表面層との間に形成される中間層としては、シリコン、タングステン、タンタル、ニオブウムおよび窒化アルミニウムよりなる群から選ばれた少なくとも1種からなるものである。また、中間層としては、上記元素とともに、窒素や炭素が含有されていてもよい。中間層の形成方法としては、例えばマグネトロンスパッタ蒸着法を挙げることができる。形成される中間層の膜厚は、0.02~1.0 μmであることが好ましい。

【0014】

【実施例】以下、本発明の実施例について説明するが、本発明はこれらによって限定されるものではない。

(実施例1) 直径20mm、厚さ6mmのタングステンカーバイド合金(WC-Co合金)「RCC-FN」(日本タングステン社製)を用い、曲率半径がそれぞれ46mmおよび200mmの凹面状の成形面を有する上型および下型を作製し、これらの型の成形面を超微細なダイヤモンド砥粒により鏡面に研磨した。

【0015】次いで、図1に示すように、それぞれの型1の成形面に炭化ホウ素化合物からなる表面層2を形成して本発明の光学ガラス素子成形用金型(後記表1の試

料No. 1~6)を製造した。表面層2の形成は、直流マグネトロンスパッタ蒸着法により、下記の条件に従って行った。

ターゲット:B, C焼結ターゲット「NPB-1」(日本タングステン社製)

スパッタ条件: 直流マグネトロンスパッタ

放電電力: 1.0KW

導入ガス: アルゴンガス(真空度約 $9 \times 10^{-4}$  Torr)

基板加熱温度: 400℃

なお、炭化ホウ素化合物の存在はX線回析評価により確認し、ホウ素化合物の含有量はX線マイクロアナライザー(XMA)で推定した。形成された表面層の状態を光学顕微鏡で観察し、そのときの成形面の表面粗さ(平均二乗粗さ、以下「RMS値」ともいう。)を測定したところ100Å以下(100~80Å)であった。

【0016】光学ガラス素子成形用金型(試料No. 1~6)の各々を図3に示すプレス成形機にセットした。同図において、4および5は光学ガラス素子成形用金型であり、4は上型、5は下型である。6は上型用加熱ヒータ、7は下型用加熱ヒータ、8は上型用ピストンシリンダー、9は下型用ピストンシリンダー、10は光学ガラス素子材料であり、この例においては酸化鉛(PbO)70重量%、シリカ(SiO<sub>2</sub>)27重量%および微量成分3重量%からなる酸化鉛系光学ガラス(重フリント系ガラス)であって、半径10mmの球状に加工した塊状物を用いた。11は光学ガラス素子材料10の供給用治具、12はプレス成形で得られる光学ガラス素子の取出し口、13は光学ガラス素子材料10の予備加熱炉、14はカバーである。

【0017】予備加熱炉13で加熱された光学ガラス素子材料10を、520℃に保持されている上型4および下型5の間に供給配置し、窒素雰囲気中、約40kg/cm<sup>2</sup>のプレス圧で2分間保持し、その後、そのままの状態では上下の型を300℃まで冷却して、プレス成形された光学ガラス素子を取り出し口12より取り出した。以上の操作により、光学ガラス素子の成形工程が完了する。なお、成形された光学ガラス素子は型の成形面に付着することなく容易に取り出され、離型性は極めて良好であった。また、以下の実施例においても同様に離型性は良好であった。

【0018】以上の工程を繰り返して3000回行った後、上型4および下型5をプレス成形機より取り外して、成形面の表面状態を光学顕微鏡で観察し、そのときの表面粗さ(RMS値)を測定したところ400Å以下であり、成形前と比較して300Å以内の劣化がみられたが、レンズ成形性能上の問題はなく、光学特性の優れたレンズが得られた。

【0019】(実施例2) 実施例1と同様にして、金型基材の成形面に、膜厚がそれぞれ0.05 μmおよび2.3 μmの表面層を形成して本発明の光学ガラス素子成形用金型(後記表1の試料No. 7~8)を製造した。実施例1と同様にして、成形面の表面粗さ(RMS値)を測定し

たところ、膜厚  $2.3\mu\text{m}$  (試料No.8) の場合  $90\sim 200\text{Å}$  と実施例1より大きくなっており、また局部的にRMS値が  $500\sim 1000\text{Å}$  と大きい箇所があった。

【0020】実施例1と同様にして、光学ガラス素子成形用金型(試料No.7~8)の各々をプレス成形機にセットし、光学ガラス素子の成形工程を繰り返して3000回行ったところ、膜厚が  $0.05\mu\text{m}$  (試料No.7) の場合、成形面の外周付近で一部表面層の剥離を生じた。以上の結果から、表面層の膜厚は  $0.1\sim 2.0\mu\text{m}$  の範囲にあることが適しているといえる。

【0021】(実施例3) 実施例1と同様にして、曲率半径がそれぞれ  $46\text{mm}$  および  $200\text{mm}$  の凹面状の成形面を有する上型および下型を作製し、これらの型の成形面を超微細なダイヤモンド砥粒により鏡面に研磨した。

【0022】次いで、図2(イ)に示すように、型1の成形面に、シリコン(試料No.9)、タングステン(試料No.10)、タンタル(試料No.11)、窒化アルミニウム(試料No.12)からなる中間層3をそれぞれ形成した。中間層3の形成は、ターゲット材料として、シリコン、タングステン、タンタル、窒化アルミニウムの各材料を用いたこと以外は実施例1における表面層の形成と同一の条件で、直流マグネトロンスパッタ蒸着法により行った。形成された膜厚は表1に示すように、シリコン層で  $0.02\mu\text{m}$ 、タングステン層で  $0.05\mu\text{m}$ 、タンタル層で  $0.1\mu\text{m}$ 、窒化アルミニウム層で  $0.5\mu\text{m}$  である。

【0023】次いで、図2(ロ)に示すように、中間層3が形成された成形面上に、実施例1と同様にして炭化ホウ素化合物からなる膜厚  $1\mu\text{m}$  の表面層2を形成して本発明の光学ガラス素子成形用金型(後記表1の試料No.9~12)を製造した。実施例1と同様にして、成形面の表面粗さ(RMS値)を測定したところ、 $80\sim 150\text{Å}$  であり、光学特性上良好であった。なお、膜厚  $1.0\mu\text{m}$  を越える中間層を形成した後、炭化ホウ素化合物からなる膜厚  $1\mu\text{m}$  の表面層を形成した場合、成形面の表面粗さ(RMS値)は局部的に  $500\text{Å}$  を超える箇所があった。以上の結果から、中間層の膜厚は  $0.02\sim 1.0\mu\text{m}$  の範囲にあることが適しているといえる。

【0024】実施例1と同様にして、光学ガラス素子成形用金型(試料No.9~12)の各々をプレス成形機にセットし、光学ガラス素子の成形工程を繰り返して3000回行った後、上型4および下型5をプレス成形機より取り外して、成形面の表面粗さ(RMS値)を測定したところ  $300\text{Å}$  以下であり、成形前と比較して  $150\text{Å}$  以内の劣化が生じただけで、レンズ成形性能上何ら問題はなかった。

【0025】(実施例4) 実施例1と同様にして、曲率

半径がそれぞれ  $46\text{mm}$  および  $200\text{mm}$  の凹面状の成形面を有する上型および下型を作製し、これらの型の成形面を超微細なダイヤモンド砥粒により鏡面に研磨した。

【0026】次いで、それぞれの型の成形面に炭化ホウ素化合物と炭素を主体とした混合物からなる表面層を形成して本発明の光学ガラス素子成形用金型(後記表1の試料No.13~16)を製造した。表面層の形成は、下記に示すターゲットを用いたこと以外は実施例1と同様の条件で行った。ターゲット：炭素ターゲット「IG-510」(東洋炭素社製)の表面に、厚さ  $1\text{mm}$  の炭化ホウ素化合物の焼結板を一定面積比で配置したもの。但し、各炭素ターゲットと炭化ホウ素化合物の面積比は次のとおりである。

面積比(試料No.13) 炭化ホウ素/炭素 =  $0.03$

(試料No.14) 炭化ホウ素/炭素 =  $0.08$

(試料No.15) 炭化ホウ素/炭素 =  $0.25$

(試料No.16) 炭化ホウ素/炭素 =  $0.45$

実施例1と同様にして、成形面の表面粗さ(RMS値)を測定したところ、 $100\sim 70\text{Å}$  であり良好であった。

【0027】実施例1と同様にして、光学ガラス素子成形用金型(試料No.13~16)の各々をプレス成形機にセットし、光学ガラス素子の成形工程を繰り返して3000回行った後、成形面の表面粗さ(RMS値)を測定したところ  $450\text{Å}$  以下であり、成形前と比較して  $350\text{Å}$  以内の劣化が生じただけで、レンズ成形性能上何ら問題はなかった。

【0028】(比較例1) 実施例1と同様に、WC-Co合金「RCC-FN」を用いて上型および下型を作製し、これらの金型基材の成形面に、プラスチック成形用金型の保護層として通常用いられている窒化チタン層を、膜厚が  $1\mu\text{m}$  となるようイオンプレーティング蒸着法により形成して成形用金型(試料No.17)を製造した。実施例1と同様にして、成形面の表面粗さ(RMS値)を測定したところ、 $100\text{Å}$  以下であり、光学的に良好な状態であった。

【0029】実施例1と同様にして、成形用金型(試料No.17)をプレス成形機にセットし、光学ガラス素子の成形工程を繰り返して3000回行ったところ、成形面への異物の付着が認められ、更に窒化チタン層の一部に剥離を生じた。このため、成形レンズの面形状が劣化し、また成形レンズの金型からの離型性が低下し、成形加工上問題となった。

【0030】各実施例における表面粗さ(RMS値)の測定値および離型性の評価を表1に示す。

【0031】

【表1】

	試料 番号	中間層		表面層		RMS値(A)		離型性
		物質	膜厚 ( $\mu\text{m}$ )	ホウ素含有量 (重量%)	膜厚 ( $\mu\text{m}$ )	成形前	3000回 成形後	
実施例 1	1	—	—	約70~80	0.1	100 ~ 80	400 以下	良 好
	2	—	—	約70~80	0.5			
	3	—	—	約70~80	0.7			
	4	—	—	約70~80	1.0			
	5	—	—	約70~80	1.5			
	6	—	—	約70~80	2.0			
実施例 2	7	—	—	約70~80	0.05	100 ~70	一部 膜剥離	やや 困難
	8	—	—	約70~80	2.3	200 ~90	局部的に 500以上	良 好
実施例 3	9	シリコン	0.02	約70~80	1.0	150 ~ 80	300 以下	良 好
	10	タングス テン	0.05	約70~80	1.0			
	11	タンタル	0.1	約70~80	1.0			
	12	窒化アル ミニウム	0.5	約70~80	1.0			
実施例 4	13	—	—	約5	1.3	100 ~ 70	450 以下	良 好
	14	—	—	約10	1.3			
	15	—	—	約30	1.3			
	16	—	—	約50	1.3			
比較例 1	17	—	—	0	1.0	100 ~ 60	膜剥離 異物付着 発生	不 良

## 【0032】

【発明の効果】以上のように、本発明の光学ガラス素子成形用金型は、高温でも安定で耐酸化性、加工性に優れ精密加工が容易である。そして、その成形面は光学ガラス素子材料に対して不活性であり、成形後において離型性に優れ、長時間のプレス成形に供した場合でも保護膜が加熱酸化されることなく、保護膜の剥離、クラックの発生、表面形状の変化などの不具合が生じにくく十分な耐久性を有する。このため、3000回プレス成形した後においても高精度のガラス素子成形物を得ることができ

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## 【図面の簡単な説明】

【図1】本発明の光学ガラス素子成形用金型の一例を示す説明用断面図である。

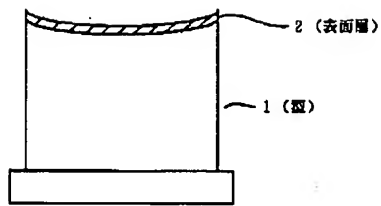
【図2】本発明の光学ガラス素子成形用金型の他の例を示す説明用断面図である。

【図3】本発明の光学ガラス素子成形用金型がセットされたプレス成形機を示す説明図である。

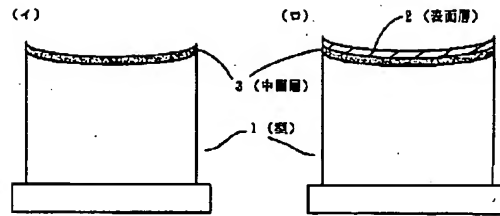
## 【符号の説明】

- |                |              |
|----------------|--------------|
| 1 型            | 2 表面層        |
| 3 中間層          | 4 上型         |
| 5 下型           | 6 上型加熱ヒータ    |
| 7 下型加熱ヒータ      | 8 上型用ピストン    |
| シリンダー          |              |
| 9 下型用ピストンシリンダー | 10 光学ガラス素子材料 |
| 11 供給用治具       | 12 取出し口      |
| 13 予備加熱炉       | 14 カバー       |
| 15 金型基材        |              |

【図1】



【図2】



【図3】

